



PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Inventor: Junji KIDO et al.

Entitled: AN ORGANIC ELECTROLUMINESCENT DISPLAY DEVICE

VERIFICATION OF TRANSLATION

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

I, the below named translator, hereby declare that:

My name and post office address are as stated below.

That I am knowledgeable in the English language and in the language of the below identified document(s) and I believe the attached English translation to be true and complete translation(s) of these document(s).

The document(s) for which the attached English translation(s) is being submitted is Japanese Patent Application No.2000-128766. A certified copy(copies) of this Japanese application(s) is attached.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: 10, 4, 2001

Full Name of the Translator (Typed): Wataru Ogura

Signature of the Translator:

Post Office Address of the Translator:

Ohno Senkawa Build. 2F, 23-7, Kanamecho 3-chome

Toshima-ku Tokyo, 171-0043, Japan

[KIND OF DOCUMENT] Patent Application Form

[REFERENCE NO.] 12P182

[ADDRESS TO] Director of Japanese Patent Office

[I. P. C.] H05B 33/08

5 [INVENTOR]

[ADDRESS] 6-6, Chuo-2-chome, Yonezawa-shi, Yamagata-ken

[NAME] Junji Kido

[INVENTOR]

10 [ADDRESS] c/o Tohoku Pioneer Corporation, 3146-7, Hachiman-Para,  
4-chome, Yonezawa-shi, Yamagata-ken

[NAME] Hitoshi Nakata

[INVENTOR]

[ADDRESS] c/o Tohoku Pioneer Corporation, 3146-7, Hachiman-Para,  
4-chome, Yonezawa-shi, Yamagata-ken

15 [NAME] Teruo Tohma

[INVENTOR]

[ADDRESS] c/o Tohoku Pioneer Corporation, 3146-7, Hachiman-Para,  
4-chome, Yonezawa-shi, Yamagata-ken

[NAME] Ryuji Murayama

20 [INVENTOR]

[ADDRESS] c/o Tohoku Pioneer Corporation, 3146-7, Hachiman-Para,  
4-chome, Yonezawa-shi, Yamagata-ken

[NAME] Toshinao Yuki

[APPLICANT]

25 [ID CODE] 000221926

[NAME] Tohoku Pioneer Corporation

[REPRESENTATIVE] Soichi Ishijima

[APPLICANT]

[ID CODE] 597011728

[NAME] Junji Kido

[PROCURATOR]

[ID CODE] 100092392

5 [ATTORNEY] Wataru OGURA

[INDICATION OF FILING FEE]

[No. OF PREPAYMENT REGISTER] 011660

[ACCOUNT OF PAYMENT] 21000

[LIST OF DOCUMENTS]

10	[KIND OF ARTICLE] SPECIFICATION	1
	[KIND OF ARTICLE] DRAWINGS	1
	[KIND OF ARTICLE] ABSTRACT	1

## [KIND OF DOCUMENT] SPECIFICATION

## [TITLE OF INVENTION]

## AN ORGANIC ELECTROLUMINESCENT DISPLAY DEVICE

## 5 [WHAT IS CLAIMED IS]

[CLAIM 1] An organic electroluminescent display device involving at least one carrier-transporting layer composed of a liquid crystal substance and at least one organic luminous layer sandwiched between a transparent electrode and a backside electrode each held in parallel to  
10 the other,

wherein said display device is driven as a liquid crystal display device or as an electroluminescent display device in response to magnitude of an applied voltage.

[CLAIM 2] The organic electroluminescent display device according to  
15 Claim 1, wherein the organic luminous layer is made of a polymer.

[CLAIM 3] The organic electroluminescent display device according to Claim 1, wherein the organic luminous layer is made of a low molecule-dispersed polymer.

[CLAIM 4] The organic electroluminescent display device according to  
20 Claim 1, wherein the organic luminous layer is a bilayer of a polymer and a monomer.

[CLAIM 5] The organic electroluminescent display device according to Claim 1-4, wherein the carrier-transporting layer is a nematic liquid crystal layer.

25 [CLAIM 6] The organic electroluminescent display device according to Claim 1-6, wherein the carrier-transporting layer is a liquid crystal layer dispersing a low-molecular carrier-transporting substance therein.

[CLAIM 7] An organic electroluminescent display device involving at least one carrier-transporting layer and at least one organic luminous layer composed of a liquid crystal substance sandwiched a transparent electrode and a backside electrode held in parallel to said transparent electrode,  
5 electrode,

wherein said display device is driven as a liquid crystal display device or as an electroluminescent display device in response to magnitude of an applied voltage.

[CLAIM 8] The organic electroluminescent display device according to  
10 Claim 7, wherein the carrier-transporting layer is made of a polymer.

[CLAIM 9] The organic electroluminescent display device according to Claim 7, wherein the carrier-transporting layer is made of a low molecule-dispersed polymer.

[CLAIM 10] The organic electroluminescent display device according to  
15 Claim 7, wherein the carrier-transporting layer is a bilayer of a polymer and a monomer.

[CLAIM 11] The organic electroluminescent display device according to Claim 7-10, wherein the organic luminous layer is a nematic liquid crystal layer.

[CLAIM 12] An organic electroluminescent display device involving an organic luminous layer and a carrier-transporting layer, either one or both of which contains a liquid crystal, sandwiched between a transparent electrode and a backside electrode,

wherein said display device is driven as a liquid crystal display  
25 device or as an electroluminescent display device in response to magnitude of an applied voltage.

[CLAIM 13] The organic electroluminescent display device according to Claim 1-12, wherein the liquid crystal layer contains two or more of

different organic compounds.

## [DETAILED DESCRIPTION OF THE INVENTION]

[0001]

### 5 [INDUSTRIAL APPLICATION]

The present invention relates to an organic electroluminescent display device which is also driven as a liquid crystal display device.

[0002]

### [PRIOR ARTS]

10 A conventional electroluminescent display device has the structure that a transparent electrode (an anode), a carrier-transporting layer, an organic luminous layer and a backside electrode (a cathode) are successively laid on a transparent substrate. A plurality of transparent electrodes are aligned along X-X direction, while a plurality of backside  
15 electrodes are aligned along Y-Y direction, so as to make up XY matrix.

When a driving current is supplied to a predetermined position on XY matrix through the transparent and backside electrodes, a hole from the anode recombines with an electron from the cathode in the organic luminous layer. An organic luminous molecule, which is excited by  
20 the recombination, emits light. The light is emitted through the transparent electrode and the transparent substrate to the outside. [0003]

[0003]

Since the organic electroluminescent display device has the feature that the organic luminous layer itself emits light, a clear image is  
25 reproduced as compared to the liquid crystal display device. However, power consumption for driving the organic electroluminescent display device is unfavorably greater than that for the liquid crystal display device using reflection of outside light.

The liquid crystal display device reproduces a clear image with high contrast under a light condition, but an image is hardly distinguished at night or in a dark place. Shortage of luminance is supplemented by backlight in order to solve difficulty to distinguish an  
5 image. Use of backlight means increase of power consumption.

[0004]

Such difficulty to distinguish an image is overcome by lamination of an electroluminescent element on a liquid crystal display device, as disclosed in Utility Model Publication No. 59-181422. The proposed liquid  
10 crystal display device reproduces an image distinguishable in dark place, due to planar emission of the electroluminescent element. The liquid crystal display device is also made thinner than a known liquid crystal display device having an electroluminescent element provided at the back side, since the electroluminescent element is directly laid on the liquid  
15 crystal display device.

[0005]

#### [PROBLEMS TO BE SOLVED BY THE INVENTION]

The liquid crystal display device disclosed in Utility Model Publication No. 59-181422 is fabricated by positioning a liquid crystal  
20 element composed of a transparent electrode, an oriented film, a polarizing plate, a spacer and a liquid crystal layer between a couple of glass substrates, and then forming an electroluminescent element on one of the glass substrates. Since the electroluminescent element is merely laid on the liquid crystal element, such the liquid crystal display device is  
25 necessarily manufactured by a complicated process with increased number of lamination. The increased number of lamination makes it difficult to reduce a thickness of the display device.

[0006]

## [MEANS TO SOLVE THE PROBLEMS]

The present invention aims at provision of a new electroluminescent element, which reproduces a distinct image with reduced power consumption. An object of the present invention is to  
5 bestow a carrier-transporting layer and/or an organic luminous layer with faculty as a liquid crystal, so that the new display device acts as an electroluminescent display device at night or in a dark place without lighting and also as a liquid crystal display device at a daytime or in a lighting place.

10 The newly proposed organic electroluminescent display device has one or both of a carrier-transporting layer and an organic luminous layer bestowed with faculty of a liquid crystal, so as to be driven as a liquid crystal display device or as an electroluminescent display device in response to magnitude of a drive voltage. For instance, it is driven as a  
15 liquid crystal display device, which reproduces an image with variable contrast, at a voltage lower than a light emission initiating potential, and as an electroluminescent display device at a voltage higher than a light emission initiating potential, due to the feature of a conventional organic electroluminescent element which need a higher drive voltage. Such  
20 change of display mechanism saves power consumption.

Of course, it is predicted that the organic electroluminescent element can be driven at a voltage lower than that for a liquid crystal with progress of technology on an organic electroluminescent element. In such a case, display mechanism will be switched between the  
25 electroluminescent display device and the liquid crystal display device, accounting distinctness of an image.

[0007]

The new organic electroluminescent display device having a



carrier-transporting layer bestowed with faculty as a liquid crystal is of the structure that at least one carrier-transporting layer composed of a liquid crystal and at least one organic luminous layer are sandwiched between a transparent electrode and a backside electrode each held in parallel to the other. The organic luminous layer is made of a polymer, a low molecule-dispersed polymer or a bilayer of a polymer and a monomer. The carrier-transporting layer disperses a nematic liquid crystal or a low-molecular carrier-transporting substance therein.

The new organic electroluminescent element having an organic luminous layer bestowed with faculty as a liquid crystal is of the structure that at least one carrier-transporting layer and at least one organic luminous layer composed of a liquid crystal are sandwiched between a transparent electrode and a backside electrode each held in parallel to the other. In this case, the carrier-transporting layer is made of a polymer, a low molecule-dispersed polymer or a bilayer of a polymer and a monomer. The organic luminous layer contains a nematic liquid crystal therein.

[0008]

The new organic electroluminescent element having both of a carrier-transporting layer and an organic luminous layer bestowed with faculty as liquid crystals is of the structure that the carrier-transporting layer and the organic luminous layer, both of which contain liquid crystals therein, are sandwiched between a transparent electrode and a backside electrode.

Two or more of different organic compounds may be included in a liquid crystal layer, by blending a liquid crystal with an organic luminous substance for instance.

[0009]

## [FUNCTION]

The newly proposed electroluminescent display device is of structure as shown in Fig. 1. A transparent electrode 2 (an anode) is laid on a transparent substrate 1 such as glass or synthetic resin film, by vapor deposition of ITO or the like. After a carrier-transporting layer 3, an organic luminous layer 4 and a backside electrode 5 (a cathode) are successively laid thereon, the whole body is hermetically sealed with a protective layer such as a glass or metal sheet.

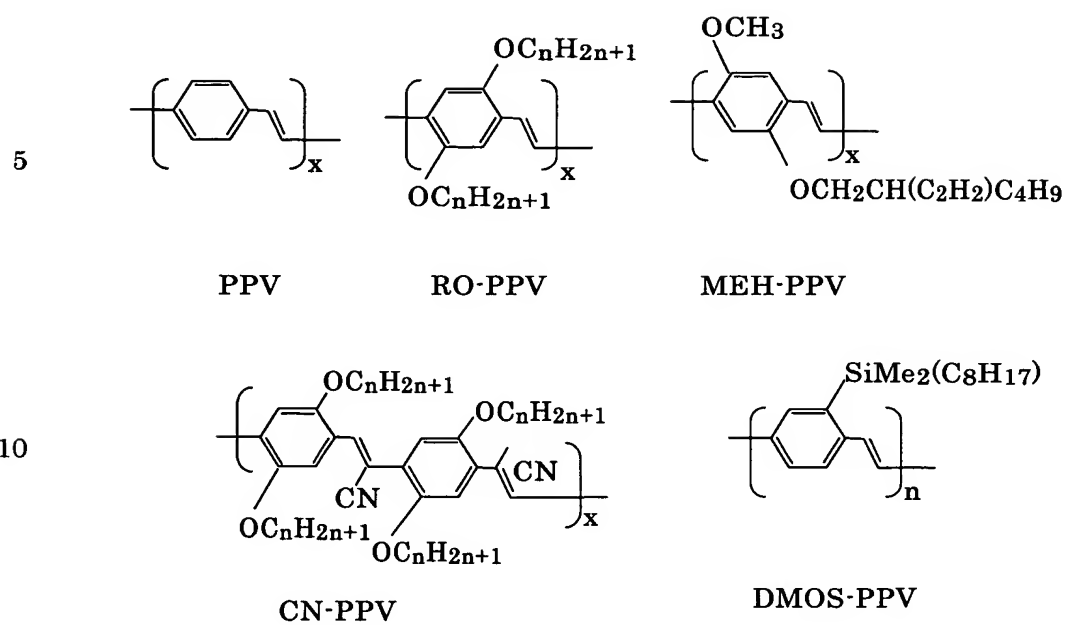
The transparent electrode 2 is formed in a striped shape extending along X-X direction, while the backside electrode 5 is formed in a striped shape extending along Y-Y direction crossing X-X direction with a right angle. The trilayer structure that an electron-transporting layer and a hole-transporting layer are placed at both sides of the organic luminous layer 4 may be also adopted.

A gap between the transparent electrode 2 and the backside electrode 5 is charged with a voltage by a driving circuit 5. When application of the voltage is controlled by signals representing an image, the organic luminous layer 4 is excited at a predetermined position on X-Y matrix. Light is emitted by excitation of the luminous layer 4 to reproduce the image. A positive direct current is ordinarily used for the charging, but a reverse voltage may be superimposed to inhibit degradation of the organic luminous layer 4.

## [0010]

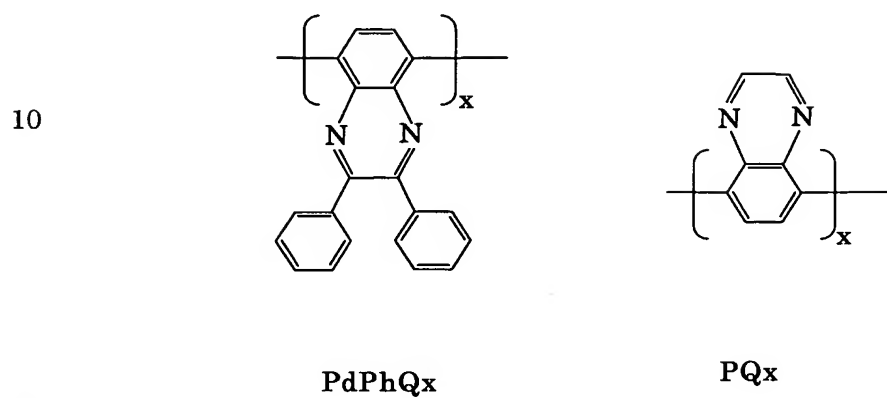
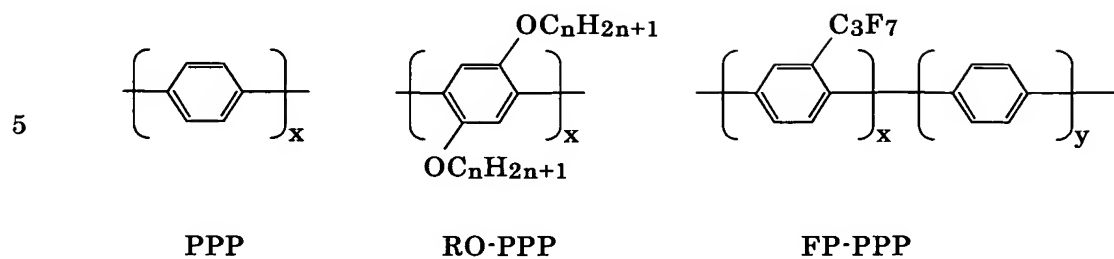
One or more of under-mentioned polymers and copolymers are solely or combinatively used for substance of the organic luminous layer 4. A polymer-type organic luminous layer may be formed by application of a liquid to form a coating layer. Hereinafter, the word "polymers" used in the specification of the present invention involves copolymers.

A group of polyparaphenylene vinylene:



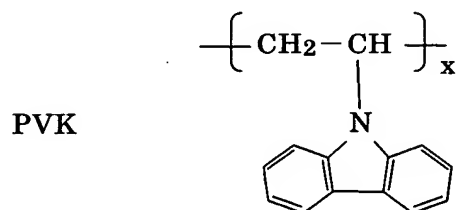
[0011]

A group of polyparaphenylene:

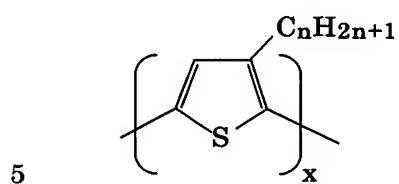


15

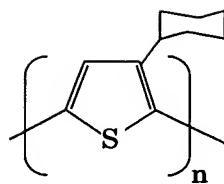
A group of polyvinylcarbazole:



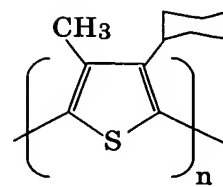
A group of polythiophene:



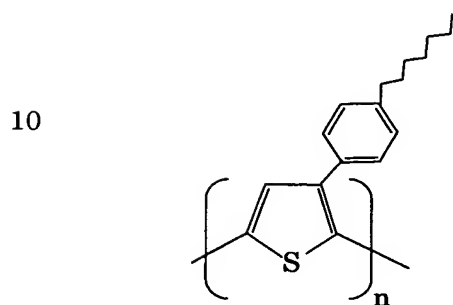
PAT



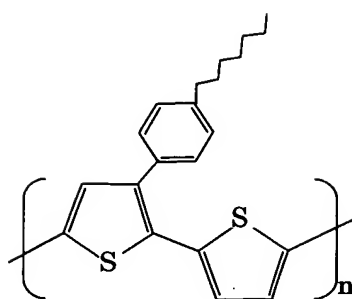
PCHT



PCHMT



POPT

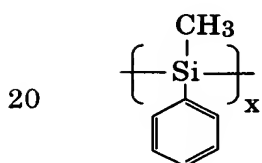


PTOPT

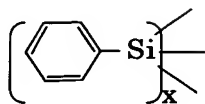
15

[0012]

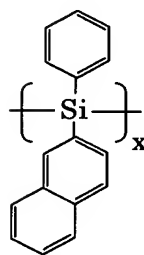
A group of polysilane:



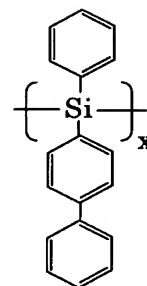
PMPS



PPS



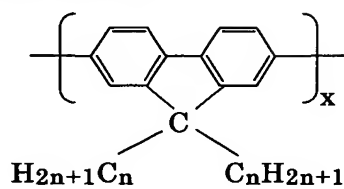
PNPS



PBPS

25 A group of poly alkylfluorene:

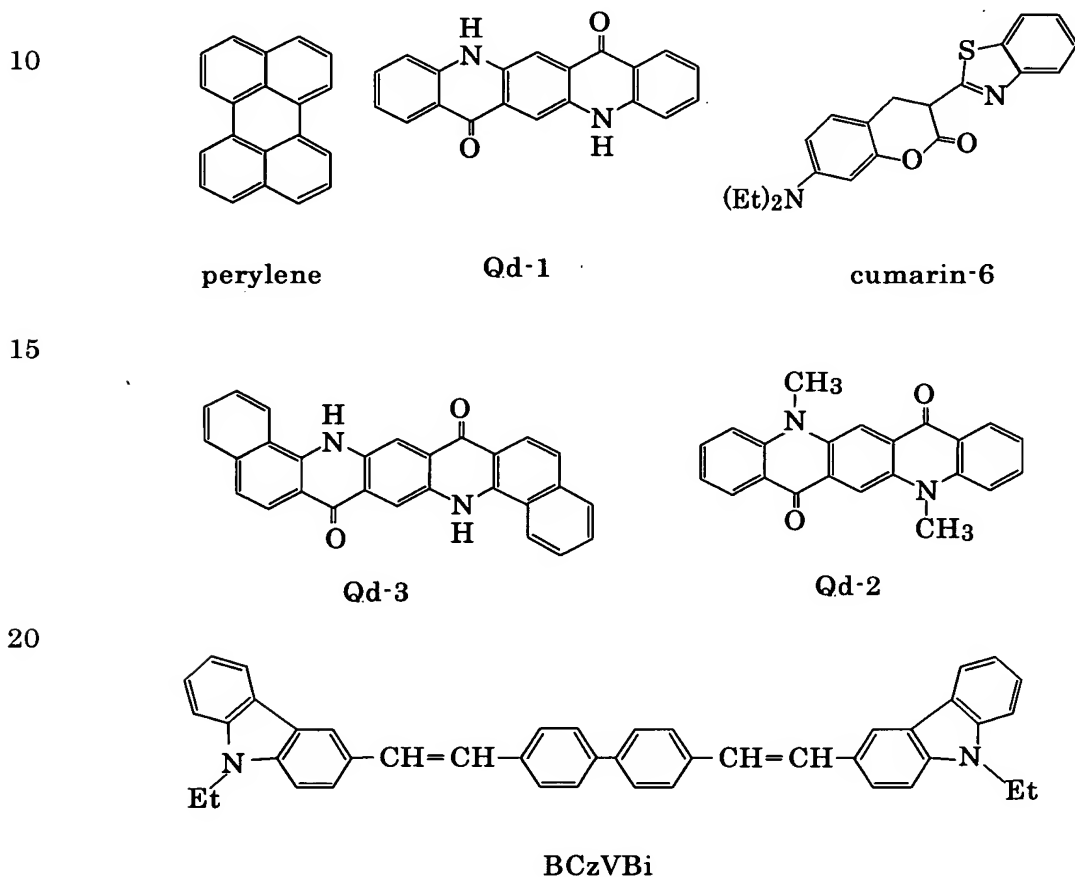
PDAF

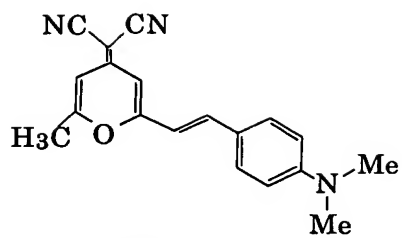


Copolymers: P(VK-co-OXD) (a random copolymer of 9-vinylcarbazole with oxadiazole vinyl monomer), PTDOXD (an alternate arrangement polymer of tetraphenyl diamine with oxadiazole)

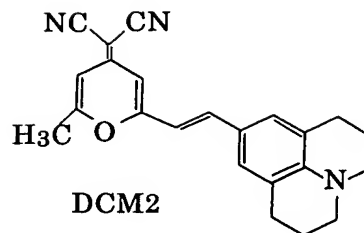
[0013]

5           A low molecule-dispersed polymer, which comprises a polymer dispersing a low molecule as a dopant, is also useful for formation of the organic luminous layer. A dopant for the purpose may be organic substances having constitutional formulas as follows.



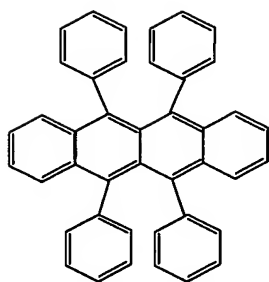


DCM1

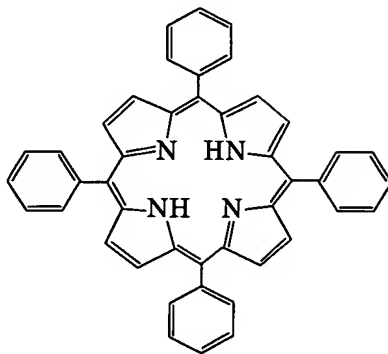


DCM2

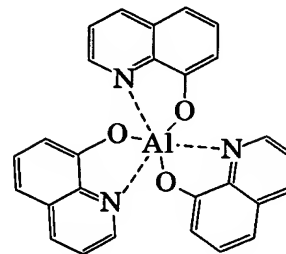
5



rubrene

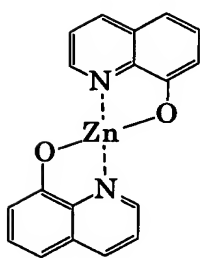


TPP

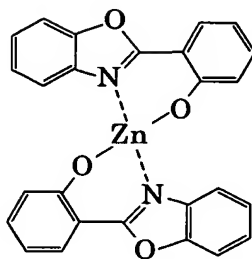
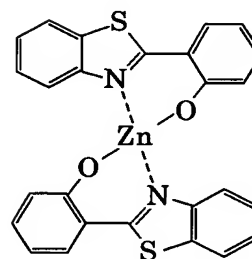


Alq3

10

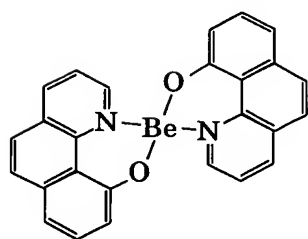


Znq2

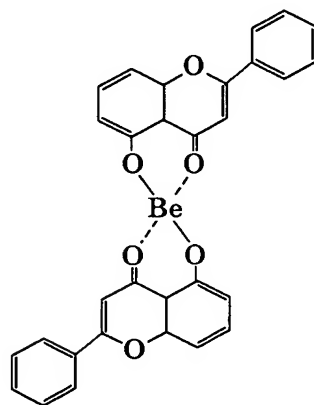
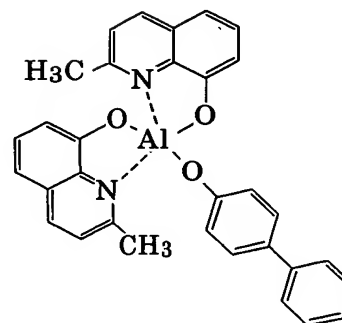
Zn(BOX)<sub>1</sub>Zn(BTZ)<sub>2</sub>

15

20



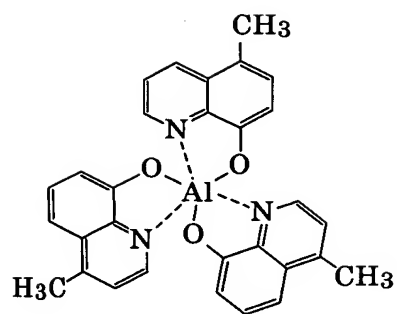
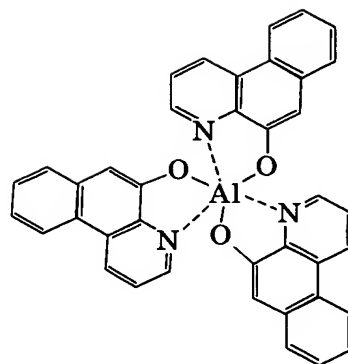
BeBq2

Be(5Fla)<sub>1</sub>

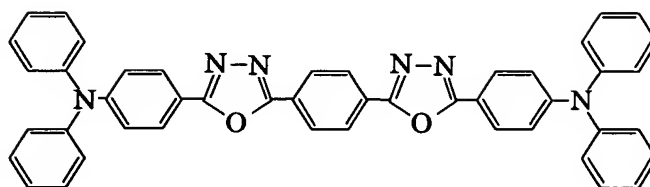
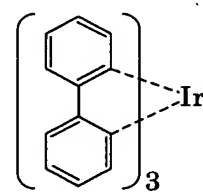
BAlq2

25

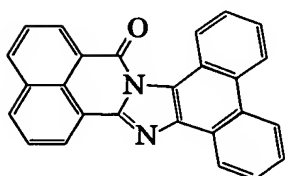
5

Almq<sub>3</sub>Alph<sub>3</sub>

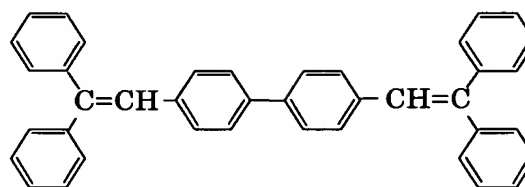
10

EM<sub>2</sub>Ir(ppy)<sub>3</sub>

15



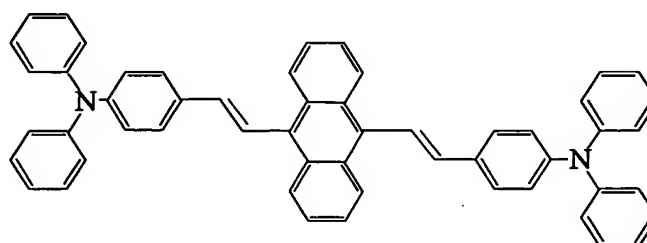
P1



DPVBi

20

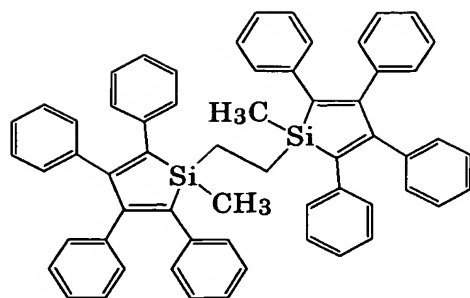
25



DSA

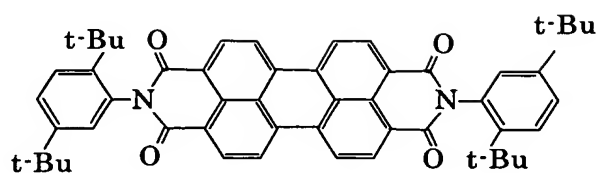


5



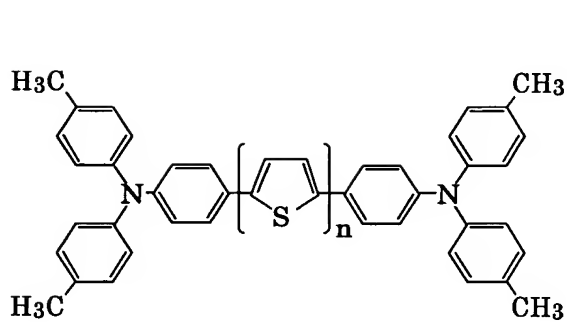
2PSP

10



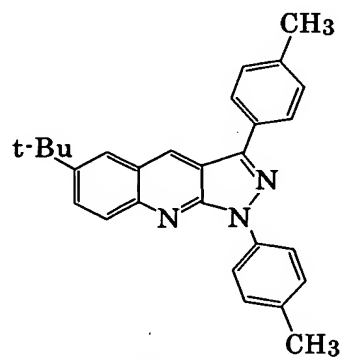
tBu-PTC

15



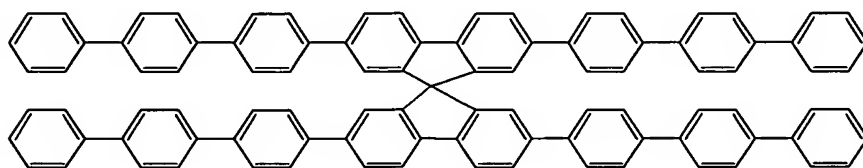
BMA-nT

20



PZ10

25



spiro-8Φ

[0014]

Use of a low molecule-dispersed polymer enables adjustment of a luminous color in correspondence with a kind and concentration of a dopant. For instance, a luminous color such as blue, green or orange is realized by doping PVK (polyvinylcarbazole) with fluorochrome such as TPB (1,1,4,4-tetraphenyl-1,3-butadiene), cumarin, DCM-1 or rubrene. In the case where such a low molecule-dispersed polymer is used for an organic luminous layer, a luminous color from a part can be advantageously differentiated from the other part by pre-doping the polymer with multiple pigments so as to diminish fluorescent of a specified pigment(s) by irradiation with light of specified wavelength. A luminous plane may be properly patterned by partial irradiation using a photomask.

[0015]

The organic luminous layer may be of bilayer structure. For instance, when 1,2,4-triazoles/aluminum complex is deposited as a hole blocking layer on a luminous layer composed of poly(N-vinylcarbazole) capable of hole transportation, the luminous layer emits blue light. A luminous color is freely changed by selection of fluorochrome for doping poly(N-vinylcarbazole).

[0016]

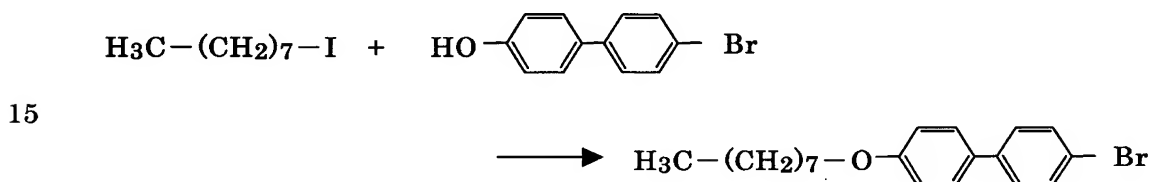
Facility as a liquid crystal display device is realized by laying a liquid crystal layer containing a nematic liquid crystal on a carrier-transporting layer or an organic luminous layer which has been used so far as organic electroluminescent substances, or by mixing such the liquid crystal in the carrier-transporting layer or the organic luminous layer. A carrier-transporting layer or an organic luminous layer may be also made of a substance which acts as both a liquid crystal and

an electroluminescence. Such the substance may be a nematic liquid crystal prepared by the following process, for instance.

[0017]

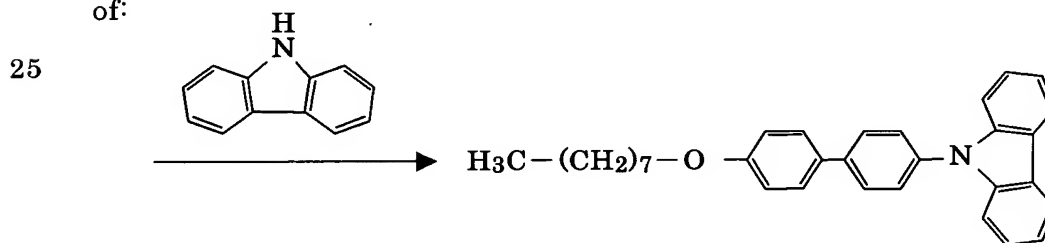
[Synthesis of a carrier-transporting liquid crystal 8-OKB  
5 (2-1,4-carbazole-4'-n-octyloxybiphenyl)]

After 4-bromo-4'-hydroxybiphenyl is dissolved in cyclohexanone, potassium carbonate and 1-iodine octane are added to the liquid and subjected to reflux reaction in a nitrogen atmosphere. When the reaction is completed, a reaction product is dissolved in diethyl ether and then  
10 filtered. A recovered filtrate is separated from the solvent, refined with ethanol, and then recrystallized. A white solid (8-OB) is produced according to the formula of:



[0018]

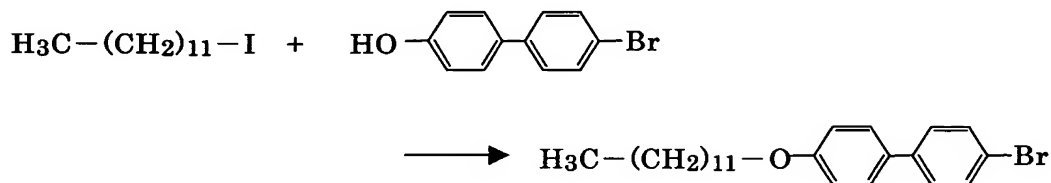
8-OB is blended with carbazole, palladium acetate, phosphine, sodium tertiary butyrate and o-xylene, and subjected to reflux reaction in  
20 a nitrogen atmosphere. At the end of the reaction, a reaction product is extracted in chloroform, washed with distilled water, refined by a column chromatography using chloroform and n-hexane at a ratio of 1:2, and then recrystallized to produce a white solid (8-OKB) according to the formula of:



[0019]

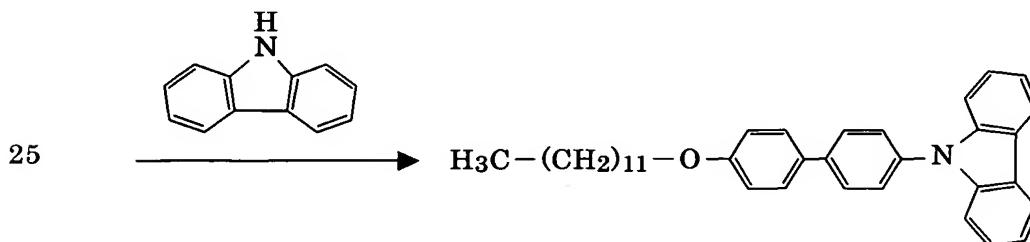
[Synthesis of a carrier-transporting liquid crystal 12-OKB (2,2,4-carbazole-4'-n-dodecaxybiphenyl)]

After 4-bromo-4'-hydroxybiphenyl is dissolved in cyclohexanone,  
 5 potassium carbonate and 1-iodine decane are added to the liquid and  
 subjected to reflux reaction in a nitrogen atmosphere. At the end of the  
 reaction, a reaction product is dissolved in diethyl ether and filtered. A  
 recovered filtrate is separated from a solvent, refined with ethanol and  
 then recrystallized to produce a white solid (12-OB) according to the  
 10 formula of:



15 [0020]

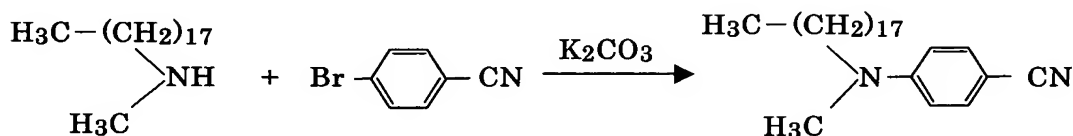
12-OB is blended with carbazole, palladium acetate, phosphine,  
 sodium tertiary butyrate and o-xylene, and subjected to reflux reaction in  
 a nitrogen atmosphere. At the end of the reaction, a reaction product is  
 extracted in chloroform, washed with distilled water, refined by a column  
 20 chromatography using chloroform and N-hexane at a ratio of 1:2, and  
 recrystallized to produce a white solid (12-OKB) according to the formula  
 of:



[0021]

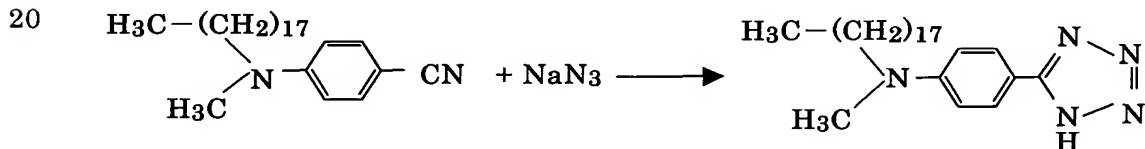
[Synthesis of 18-OXD (2,1,2-(4-n-methyl octadecyl aminophenyl)-5-(4-cyanophenyl)-1,3,4-oxadiazole)]

After N-methyl octadecylamine (Na) is dissolved in  
5 cyclohexanone, potassium carbonate and 4-bromo benzonitrile are added  
to the liquid and subjected to reflux reaction in a nitrogen atmosphere. At  
the end of the reaction, a reaction product is dissolved in chloroform and  
filtered. A recovered filtrate is separated from the solvent, and un-reacted  
matters are sublimated. In this case, a yellow solid (Nab) is obtained  
10 according to the formula of:



[0022]

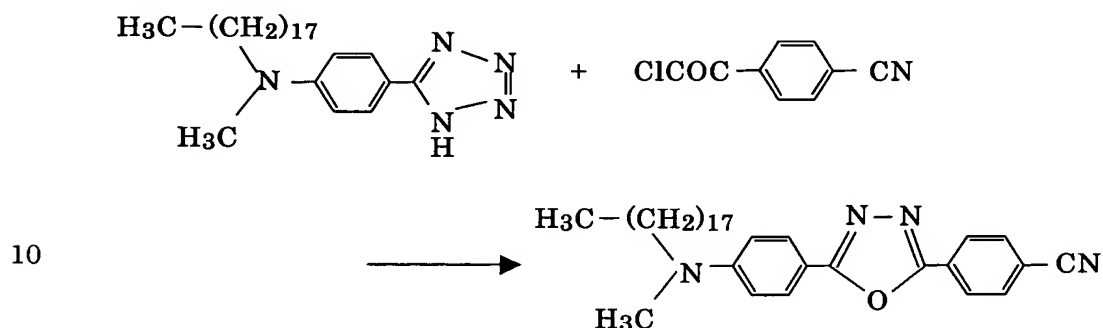
15           The yellow solid (Nab) is blended with an excessive amount of sodium azide and ammonium chloride, subjected to reflux reaction with heat in dimethylformamide, and washed with distilled water and chloroform, to produce a brown viscous matter (4NabN) according to the formula of:



[0023]

25           The product (4NabN) is dissolved in pyridine, subjected to reflux reaction with heat in a nitrogen atmosphere. The reaction is continued under the condition that 4-cyanobenzoyl chloride dissolved in pyridine is being dropped. After completion of the reaction, a reaction product is

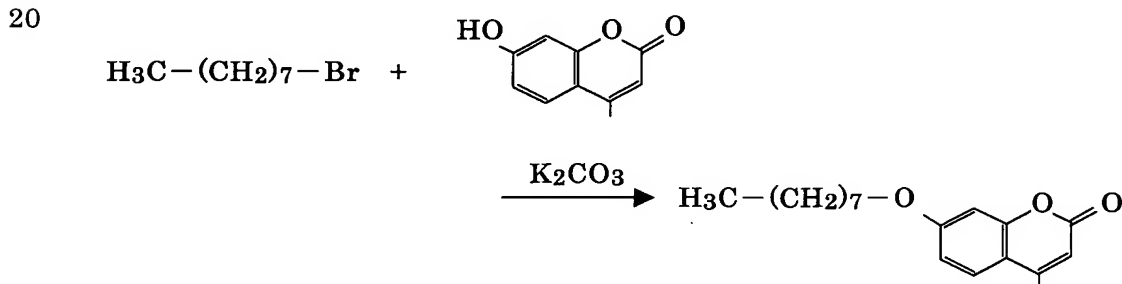
separated from pyridine, and washed with distilled water and chloroform, to produce a brown viscous matter. The brown viscous matter is refined to a brown solid by a column chromatography using ethyl acetate and n-hexane at a ratio of 3:2 and then recrystallized to a yellowish white solid (18-OXD) with methanol. The reaction to 18-OXD is:



[0024]

[Synthesis of 8-OCu (2-2,4-cumarin-4'-n-octyl)]

After 4-cumarin is dissolved in cyclohexanone, potassium carbonate and 1-iodine octane are added to the liquid, and subjected to reflux reaction in a nitrogen atmosphere. At the end of the reaction, a reaction product is dissolved in tetrahydrofuran and filtered. A recovered filtrate is separated from the solvent, and recrystallized with n-hexane, to produce a white solid (8-OCu) according to the formula of:



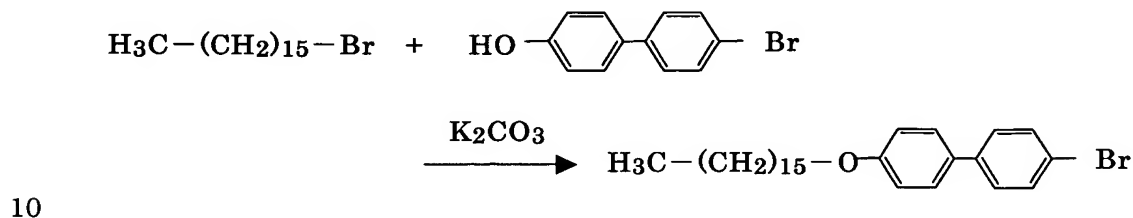
25

[0025]

[Synthesis of 16-OKB (2,3,4-carbazole-4'-n-dodecahexyl biphenyl)]

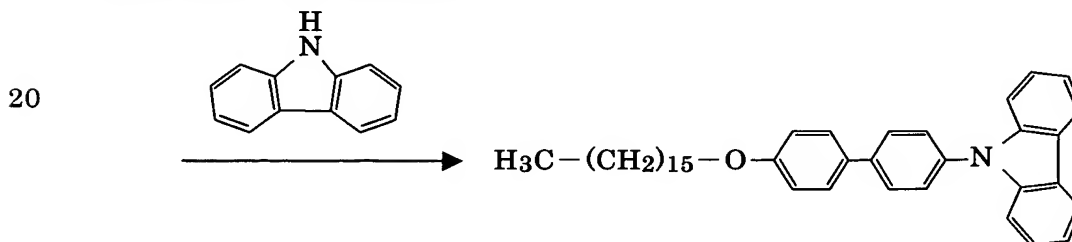
After 4-bromo-4'-hydroxybiphenyl is dissolved in cyclohexanone,

potassium carbonate and 1-bromo dodecaxyl are added to the liquid, and subjected to reflux reaction in a nitrogen atmosphere. At the end of the reaction, a reaction product is dissolved in diethyl ether and filtered. A recovered filtrate is separated from the solvent, refined with ethanol and recrystallized, to produce a white solid (16-OB) according to the formula of:



[0026]

The product 16-OB is blended with carbazole, palladium acetate, phosphine, sodium tertiary butyrate and o-xylene, and subjected to reflux reaction in a nitrogen atmosphere. At the end of the reaction, a reaction product is extracted in chloroform, washed with distilled water, refined by a column chromatography using chloroform and n-hexanone at a ratio of 1:2, and then recrystallized in ethanol, to produce a white solid (16-OKB) according to the formula of:

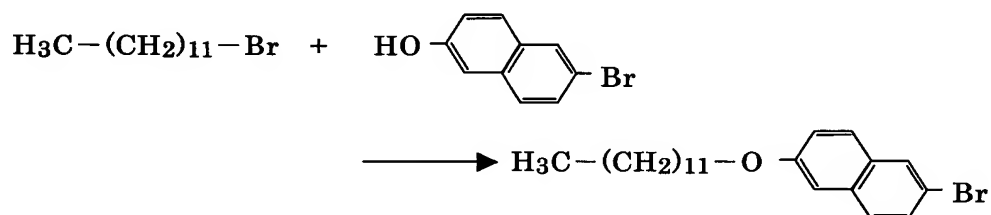


[0027]

25 [Synthesis of a bipolar carrier-transporting liquid crystal 8-PNP-O12 (2,4,2-(4'-octylphenyl)-6-dodecyloxy naphthalene)]

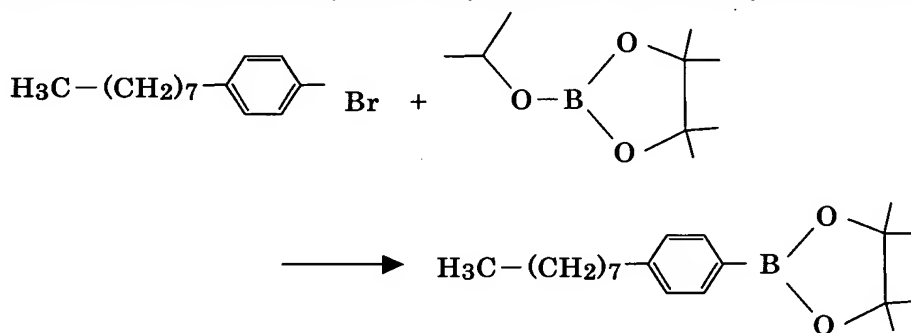
After 6-bromo-2-naphthol is dissolved in cyclohexanone, potassium carbonate and 1-bromo dodecane are added to the liquid, and

subjected to reflux reaction in a nitrogen atmosphere. At the end of the reaction, a reaction product is dissolved in diethanol, and filtered. A recovered filtrate is separated from the solvent, refined with methanol, and then recrystallized, to produce a white solid (12NaB) according to the formula of:



[0028]

4-bromo-n-octyl benzene is dissolved in tetrahydrofuran, cooled in a nitrogen atmosphere to a sub-zero temperature, and reacted with n-butyllithium at 0°C. The reaction product is re-cooled at a sub-zero temperature, and then reacted with 2-isopropoxy-4,4,5,5-tetramethyl-1,3,2-dioxo borane at a room temperature. Distilled water is added to the reaction product at the end of the reaction, and then the reaction product is washed with chloroform and salty water, and refined by a column chromatography using chloroform and n-hexanone at a ratio of 1:2, to produce a colorless transparent liquid (8BB) according to the formula of:

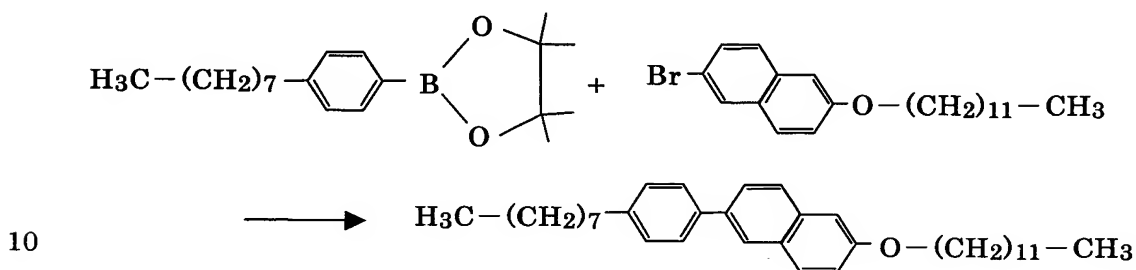


[0029]

Both 12NaB and 8BB are dissolved in tetrahydrofuran, and reacted with a potassium carbonate aqueous solution and Pd(PPh<sub>3</sub>)<sub>4</sub> at a



warm temperature. After distilled water is added to the reaction product at the end of the reaction, the reaction product is washed with chloroform and salty water, and then refined by a column chromatography using chloroform and n-hexanone at a ratio of 1:2, to produce a white solid  
 5 (8-PNP-O12) according to the formula of:



[0030]

#### [EXAMPLE]

##### Example 1:

15 After an ITO film was laid on a glass substrate (a transparent substrate 1), the substrate was washed. A positive resist material applied onto the substrate by a spin coater and then annealed at 100°C for 50 minutes, to form a resist film. The resist film was irradiated 10 seconds with a ultraviolet ray, using a photomask having a predetermined pattern.  
 20 The irradiated resist film was developed by washing with ion-exchanged water to flush solubilized resist material. Thereafter, the glass substrate was chemically etched, and the remaining resist film was dissolved off the substrate, so as to shape the ITO film (a transparent electrode 2) to a striped pattern.

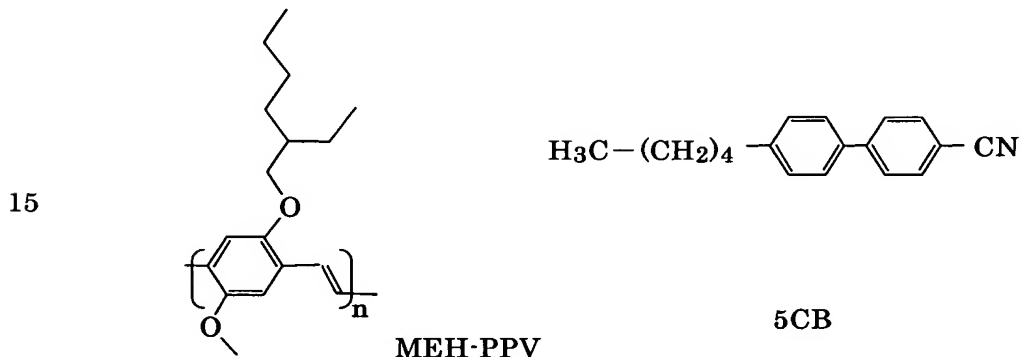
25 [0031]

After the ITO layer is patterned, an organic luminous substance MEH-PPV [poly(2-methoxy-5-ethyl hexoxy)-1,4-phenylenevinylene] was deposited on the substrate to thickness of 100nm and then rubbed. A thin

Al film was vapor deposited as a patterned backside electrode 5 on another glass substrate, and then MEH-PPV was deposited to thickness of 100nm and rubbed. These glass substrates were piled up and bonded together with epoxy resin except for a liquid crystal injecting hole. A cell gap between the substrates was adjusted to 900nm.

[0032]

A liquid crystal prepared by dispersing 12-OKB in 5CB at a ratio of 10 wt.% was used as an organic luminous substance. 12-OKB was a nematic liquid crystal, which was transferred to a liquid crystal phase near a room temperature in a state incorporated in 5CB. Schilieren texture was observed at ratios of 5 wt.%, 10 wt.% and 20 wt.%.



[0033]

20 The bonded substrates (an empty cell) were dried 1 hour at a room temperature, received in Petri dish filled with the liquid crystal, and set in a desiccator. The empty cell was evacuated by a vacuum pump, and its liquid crystal injecting hole was dipped in the liquid crystal reserved in Petri dish, so that the liquid crystal slowly flowed from Petri dish into the empty cell.

25 After a sufficient amount of the liquid crystal was poured in the empty cell, the liquid crystal injecting hole was hermetically sealed with adhesives 8 (epoxy resin), as shown in Fig. 3. Thereafter, the cell was

dried 1 hour.

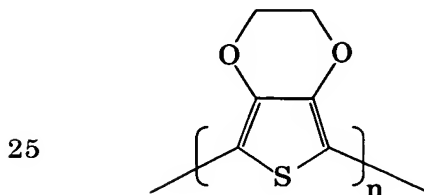
[0034]

Polarizing plates 9,10 were respectively laid on both surfaces of the cell 7, so that each polarizing plane was set parallel to the other. In this case, the surface of the cell was dark under power-off condition, but turned to light by application of 15V. Polarizing plates 9,10 were laid on both surfaces of the cell 7, so that each polarizing plane crosses to the other with a right angle on the contrary. In this case, the surface of the cell was light under power-off condition, but turned to dark by application of 15V. Turning to dark or light proved faculty as a liquid crystal display device. Light emission originated in MEH-PPV was observed, when the cell was charged with a voltage of 35V or higher. Luminance of 0.175cd/m<sup>2</sup> at most was gained at 131V with an external quantum efficiency of 0.043%. Faculty of 12-OKB as a hole-transporting substance was recognized by such the light emission.

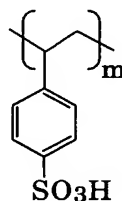
[0035]

Example 2:

A cell 7 was fabricated in the same way as Example 1 except for using PEDOT doped with PSS (polystyrene sulfonate) instead of MEH-PPV at a side of the ITO substrate. PEDOT and PSS are respectively of:



PEDOT



PSS

[0036]

Polarizing plates 9,10 were respectively laid on both surfaces of the cell 7, so that each polarizing plane was set parallel to the other. In this case, the surface of the cell was dark under power-off condition, but  
5 turned to light by application of 5V. Polarizing plates 9,10 were laid on both surfaces of the cell 7, so that each polarizing plane crossed to the other with a right angle on the contrary. In this case, the surface of the cell was light under power-off condition, but turned to dark by application of 5V. Turning to dark or light proved faculty as a liquid crystal display  
10 device. Light emission originated in MEH-PPV was observed, when the cell was charged with a voltage of 15V or higher. Luminance of  $1.04\text{cd/m}^2$  at most was gained at 90V with an external quantum efficiency of 0.045%.

[0037]

Example 3:

15 An organic electroluminescent display device, which also act as a transmission liquid crystal display device, was fabricated by pouring a liquid crystal in an empty cell in the same way as Example 2 except for formation of s transparent backside electrode instead of an Al layer without formation of an Al layer.

20 Polarizing plates 9,10 were respectively laid on both surfaces of the cell 7, so that each polarizing plane was set parallel to the other. In this case, the surface of the cell was dark under power-off condition, but turned to light by application of 14V. Polarizing plates 9,10 were laid on both surfaces of the cell 7, so that each polarizing plane crosses to the  
25 other with a right angle on the contrary. In this case, the surface of the cell was light under power-off condition, but turned to dark by application of 14V. Turning to dark or light proved faculty as a liquid crystal display device. Light emission originated in MEH-PPV was observed, when the

cell was charged with a voltage of 40V or higher. Luminance of 0.7cd/m<sup>2</sup> at most was gained at 155V with an external quantum efficiency of 0.019%.

[0038]

5 Example 4:

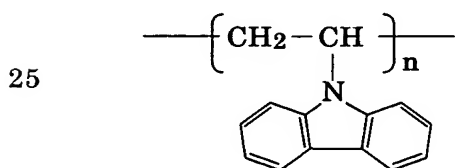
A cell was fabricated in the same way as Example 2 except for using 8-OCu instead of 12-OKB.

Polarizing plates 9,10 were respectively laid on both surfaces of the cell 7, so that each polarizing plane was set parallel to the other. In this case, the surface of the cell was dark under power-off condition, but turned to light by application of 13V. Polarizing plates 9,10 were laid on both surfaces of the cell 7, so that each polarizing plane crossed to the other with a right angle on the contrary. In this case, the surface of the cell was light under power-off condition, but turned to dark by application of 13V. Turning to dark or light proved faculty as a liquid crystal display device. Light emission originated in 8-OCu was observed, when the cell was charged with a voltage of 60V or higher. Luminance of 0.5cd/m<sup>2</sup> at most was gained at 140V.

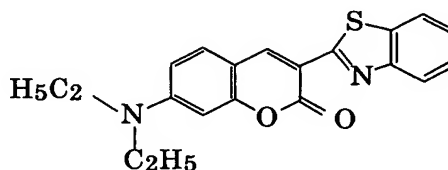
[0039]

20 Example 5:

A cell was fabricated in the same way as Example 1 except for using PVK (polyvinylcarbazole) and cumarin-6 instead of 12-OKB. PVK and cumarin-6 are respectively of:



PVK



cumarin-6

[0040]

Polarizing plates 9,10 were respectively laid on both surfaces of the cell 7, so that each polarizing plane was set parallel to the other. In this case, the surface of the cell was dark under power-off condition, but turned to light by application of 15V. Polarizing plates 9,10 were laid on both surfaces of the cell 7, so that each polarizing plane crossed to the other with a right angle on the contrary. In this case, the surface of the cell was light under power-off condition, but turned to dark by application of 15V. Turning to dark or light proved faculty as a liquid crystal display device. Light emission originated in cumarin-6 was observed, when the cell was charged with a voltage of 70V or higher. Luminance of 0.6cd/m<sup>2</sup> at most was gained at 130V.

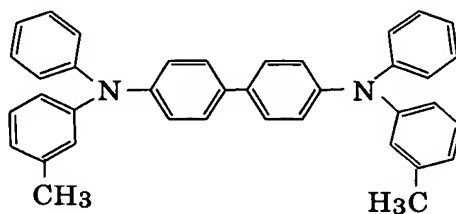
For comparison, a cell was fabricated without use of PVK. In this case, an initial voltage for light emission originated in cumarin-6 increased to 110V.

Decrease of the initial voltage means that PVK mixed in the liquid crystal act as a carrier-transporting substance, while cumarin-6 has faculty as a luminous substance.

[0041]

#### 20 Example 6:

A cell was fabricated in the same way as Example 1 except for using TPD (tetraphenyl diamine) instead of 12-OKB. TPD is of:



TPD

[0042]

Polarizing plates 9,10 were respectively laid on both surfaces of the cell 7, so that each polarizing plane was set parallel to the other. In this case, the surface of the cell was dark under power-off condition, but  
5 turned to light by application of 13V. Polarizing plates 9,10 were laid on both surfaces of the cell 7, so that each polarizing plane crossed to the other with a right angle on the contrary. In this case, the surface of the cell was light under power-off condition, but turned to dark by application of 13V. Turning to dark or light proved faculty as a reflecting liquid  
10 crystal display device. Light emission originated in MEH-PPV was observed, when the cell was charged with a voltage of 50V or higher. Luminance of  $1.2\text{cd/m}^2$  at most was gained at 120V. The result proved that the liquid crystal layer containing a low molecule carrier-transporting substance dispersed therein has faculty as a  
15 carrier-transporting layer.

[0043]

#### [EFFECT OF THE INVENTION]

The organic electroluminescent display device proposed by the present invention can be also driven as a liquid crystal display device,  
20 since a carrier-transporting layer and/or an organic luminous layer having faculty as a liquid crystal element is laminated on a transparent substrate. Due to the faculty as a liquid crystal element, the new display device is used as a liquid crystal display device at a day time or in a lighted place where an image is distinctly observed, and also as an  
25 electroluminescent display device in a dark place. Such switching of display mechanism saves power consumption. Furthermore, the new electroluminescent display device can be fabricated in a thin state without complication of process, since a liquid crystal substance is

incorporated in the carrier-transporting layer and/or the organic luminous layer of the organic electroluminescent element itself.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1 is a bird eye's view illustrating an organic  
5 electroluminescent element partially cut off.

Fig. 2 is a view for explaining driving mechanism of an organic electroluminescent display device.

Fig. 3 is a view illustrating a cell having both surfaces to which polarizing plates are stacked.

10 [EXPLANATION OF FIGURES]

1: a transparent substrate      2: a transparent electrode      3: a carrier-transporting layer      4: an organic luminous layer      5: a backside electrode      6: a driver      7: a cell      8: a bond      9, 10: polarizing plates

15



## [KIND OF DOCUMENT] ABSTRACT

## [ABSTRACT]

[OBJECT] To bestow a faculty of a liquid crystal display on an organic electroluminescent display device by provision of liquid crystal material  
5 into the carrier-transporting layer 3 and/or organic luminous layer 4, without increase of number of layers.

## [CONSTITUTION]

The new organic electroluminescent display device has a carrier-transporting layer 3 and/or an organic luminous layer 4 composed  
10 of a nematic liquid crystal or a liquid crystal dispersing a carrier-transporting low-molecule therein. When the organic luminous layer 4 is to be bestowed with faculty as a liquid crystal, it is made of a nematic liquid crystal. Both the carrier-transporting layer 3 and the organic luminous layer 4 may be bestowed with faculty as a liquid crystal.  
15 Since the liquid crystal is incorporated in the carrier-transporting layer 3 and/or the organic luminous layer 4, the display device can be driven as a liquid crystal display device in a dark place by charging with a voltage lower than a light emission initiating potential. Of course, it is driven as an electroluminescent display device when it is charged with a voltage  
20 higher than the light emission initiating potential.

[DESIGNATION OF DRAWINGS] Fig.1